Space Weather Technical Forecast

Issued on Friday, 11 March 2022 at 13:08 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Geomagnetic activity expected to increase days 3 and 4, with a G1/Minor geomagnetic storm likely. Active electron fluence.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low over the past 24 hours, with only C-class flares observed. The largest flare of the past 24 hours, a long duration C-class flare, appears to be from the large plage region to the south of AR2962, which peaked at C2.8 at 10/2057. This flare has emitted a large and wide, full halo CME, which has been analysed, and is expected to hit Earth either late on day 3 (13th March) or early on day 4 (14th March).
There are six numbered sunspot regions on the visible disc, with AR2965 the largest and also magnetically complex, but surprisingly remains dormant at present. There are also two other large groups, AR2960 and AR2964, with AR2960 also magnetically complex. Yet despite the presence of these regions only a C-class flare from a plage region has occurred. The remaining sunspots on the visible disc are small, weak and magnetically simple.

There are also numerous - mostly small - filaments on the disc at present. The largest of these lifted off the southeastern limb late in the UTC evening of 09 March, with the resultant Coronal Mass Ejection (CME) clearly discernible in coronagraphs. This event has been modelled, and counter to expectations does in fact show marginal influence is possible at Earth from at least the shock either late day 3 (13th) or more likely through day 4 (14th).

Solar Wind / Geomagnetic Activity: The solar wind, as measured by DSCOVR at L1, was mostly at background levels, briefly increasing to slightly elevated levels, with a peak of 416km/s at 11/0803UTC. The solar wind density was predominantly at average levels until 10/1641 UTC, then increased to above average levels, peaking at 32 ppcc at 10/1825 UTC, before declining to the current average levels. The IMF was weak and steady until 10/1636 UTC after which time it strengthened to temporarily become strong and peak at 18 nT at 10/2102 UTC. By the end of the period the IMF had declined back to moderate/weak levels, currently around 8 nT. The north-south component was generally very weakly negative, but increased to become temporarily moderately negative, reaching -10 nT at 10/1901 UTC, after which the Bz was variable, reaching -10 nT again at 11/0540UTC, before increasing to weakly positive at present. The phi angle was erratic, but more often negative (towards the Sun). The changes in the solar wind parameters indicated that a CME had arrived, probably the one emitted on 7th March, but this may have swept up and included the CME emitted on 5th March as well. Geomagnetic activity was mainly Quiet (Kp 1-2) but with isolated Active (Kp 4) intervals at 10/2100-2400 UTC and 11/0600-0900 UTC.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) measured at GOES 16 was at Background levels until late in the day, then became slightly elevated in response to the CME being emitted from the C-class flare, but remained below the S1 level.
The high energy electron flux (greater than 2 MeV) was High until 10/1910 UTC, with a peak

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value of 8970 pfu at 10/1720 UTC. After this time the flux rapidly dropped to background to moderate levels, as a result of the increased geomagnetic activity. The corresponding 24-hour integrated electron fluence remained above the Active (1e8 integrated pfu) level, with a steady trend, and reaching 2.88e8 integrated pfu at 11/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be Low, with further C-class flares, but with a daily Chance of rising to Moderate - the main risk being from AR2965.

Solar Wind / Geomagnetic Activity: There are now two CMEs potentially Earth-directed, the first with low confidence from the 9th March southeast quadrant filament. This may influence Earth either late day 3 (13th) or through day 4 (14th), while interacting with the CIR from CH65. Yesterday's large full halo CME has been analysed and is Earth-directed, and is expected to arrive either late on day 3 (13th) or early on day 4 (14th), and will probably be a larger impact than the 9th March CME. Meanwhile, CH65 which has passed the central meridian may bring fast wind during day 3 (13th), although this is likely to be absorbed by the large CME, which may also enhance geomagnetic activity.

Geomagnetic activity is expected to be Unsettled to Active (Kp 3-4) at first under the residual influence of yesterday's CME arrival, then decreasing mainly Quiet (Kp 0-2) later today and through tomorrow (12th). During day 3 (13th) activity is likely to increase again, becoming Unsettled to Active, either under the influence of the 9th March CME, but more likely due to the expected arrival of yesterday's full halo CME. This is likely to give a G1/Minor (Kp 5) Storm each day, but especially during days 3 and 4 (13th and 14th), with a Slight Chance of a G2 (Kp 6). possibly with the arrival of yesterday's CME. There is a chance of a G1/Minor (Kp 5) Storm each day, but especially during day 3.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain predominantly at Background levels, albeit with a slight chance of rising above-the S1 level.
The high energy (greater than 2 MeV) electron flux is currently at background to moderate levels, but there is a slight chance of a rebound today or more especially tomorrow (12th), especially at the peak of the diurnal cycles. During days 3 and 4 (13th and 14th), with an likely increase in geomagnetic activity, the electron flux is expected to decrease to background to moderate levels again.
The corresponding fluence will start above Active levels (1e8 integrated flux) before decreasing below Active through day 2 or 3, although confidence is low regarding this.

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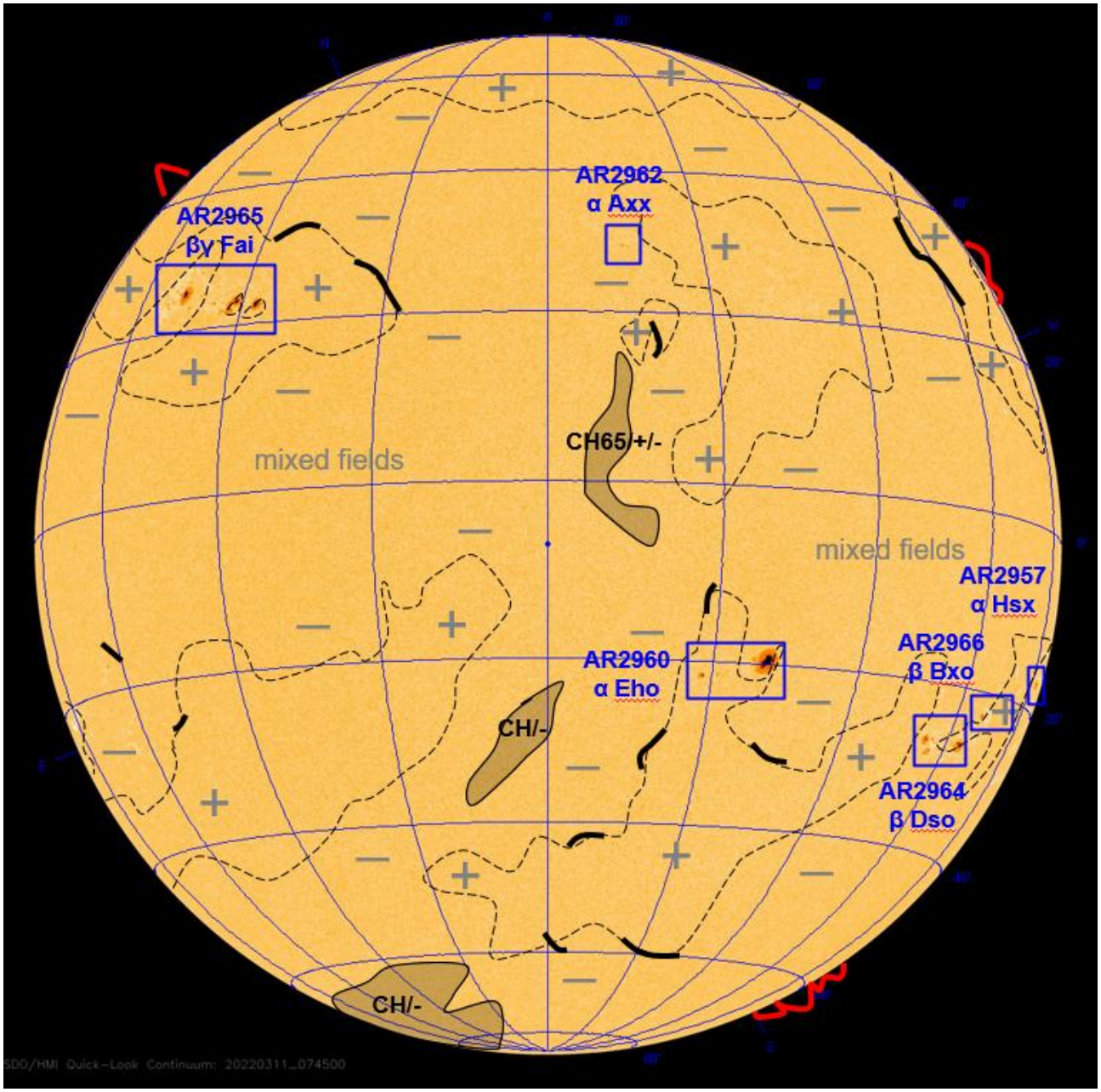
Figure 1. Solar Analysis Valid 11/0745UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are now two CMEs potentially Earth-directed, having had the arrival of one, perhaps two, CME's yesterday.

The first CME in the forecast comes with low confidence from the 9th March southeast quadrant filament. The shock from this CME may interact with the CIR from a HSS from CH65, and so influence Earth, either late day 3 (13th) or through day 4 (14th). Yesterday's full halo CME has been analysed and is Earth-directed, which is expected to arrive either late on day 3 (13th) or early on day 4 (14th), and is expected to have a larger impact than the 9th March CME. The arrival of this CME may swamp the influence of the 9th March CME and any fast wind from CH65.

Geomagnetic activity is currently decreasing to mostly Quiet conditions, after the passing of yesterday's CME, although there is a slight chance of further Unsettled intervals today and tomorrow (12th). During day 3 (13th) activity is likely to increase again, becoming Unsettled to Active, either under the influence of the 9th March CME, but more likely due to the expected arrival of yesterday's full halo CME. This is likely to give a G1/Minor (Kp 5) Storm each day, but especially during days 3 and 4 (13th and 14th), with a Slight Chance of a G2 (Kp 6).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	30	20	70	40
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
09/2300	Partial?	SE quadrant filament	36E 18S	445km/s	13/2300UTC	Possible shock, mainly outside period. Low
11/04:06	Full	NW quadrant	Approx 11W 23N	577	13/2200UTC (+/- 6hours)	Earth-directed

Figure 2: SDO 94 shows the C-class flare near AR2962, which produced the full halo CME.

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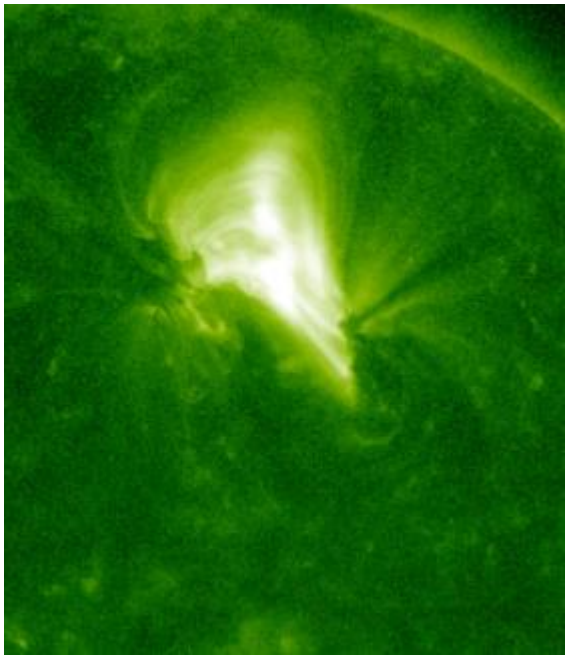

Figure 3: GOES-16 X-ray flux shows the long duration C-class flare.

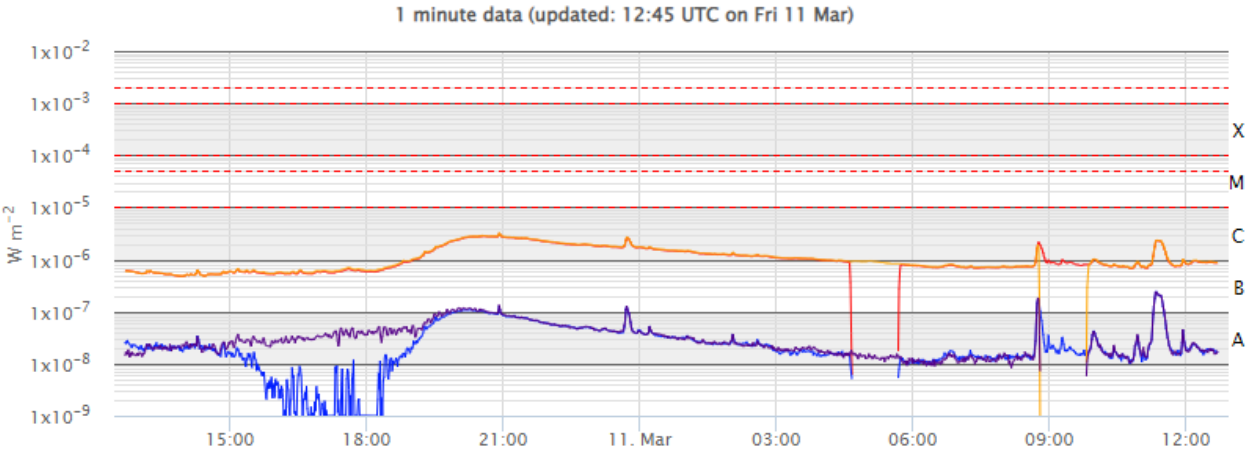

Figure 4: SOHO Lasco C3 image shows full halo CME (left) and STEREO-A shows the CME to be Earth-directed.

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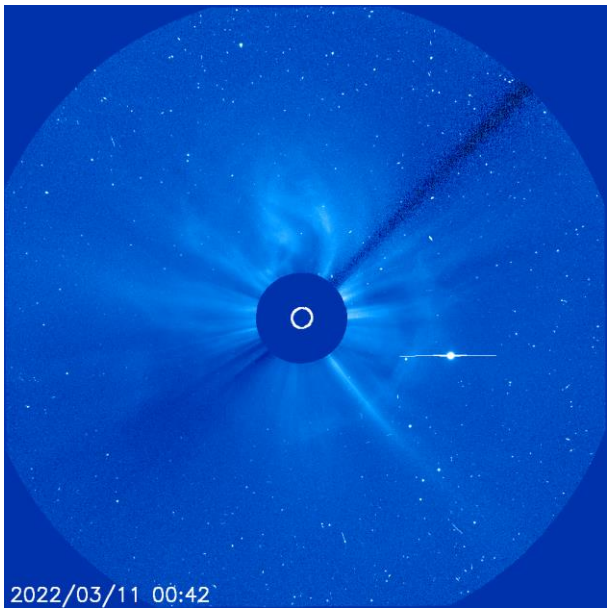

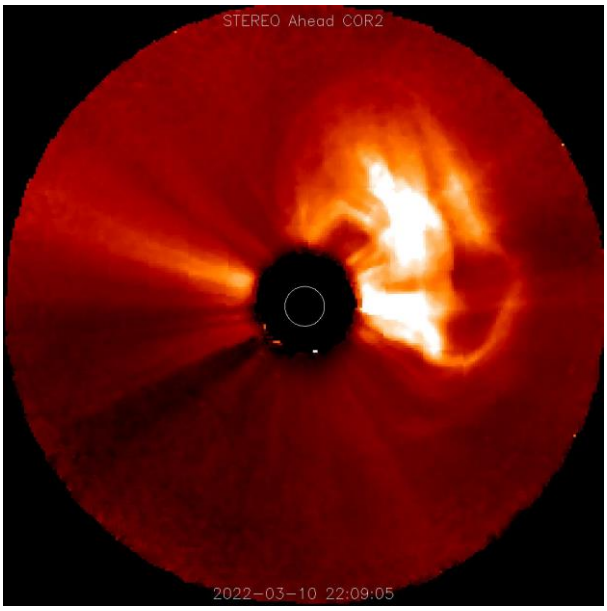

Radio Blackouts - X-Ray Flares:
There are six numbered sunspot regions, although 2964 and 2966 are hard to discern as they are so close to each other, which has implications on the risks of flares. AR2960 remains one of the most significant regions on the disc, but the penumbra on the trailing spots has diminished to become rudimentary. AR2962 is barely visible as a simple Axx/alpha region. AR2964 showed growth in the penumbra in the leading and trailing spot groups. AR2965 persists as the largest and most complex region on the visible disc.

Activity is expected to remain Low with further C-class flares likely. There remains a chance of M-class flares, most likely from AR2965, despite its apparent dormant state at present.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	20	20	20	20
Very Active	R3 to R5 X Class	No	1	1	1	1

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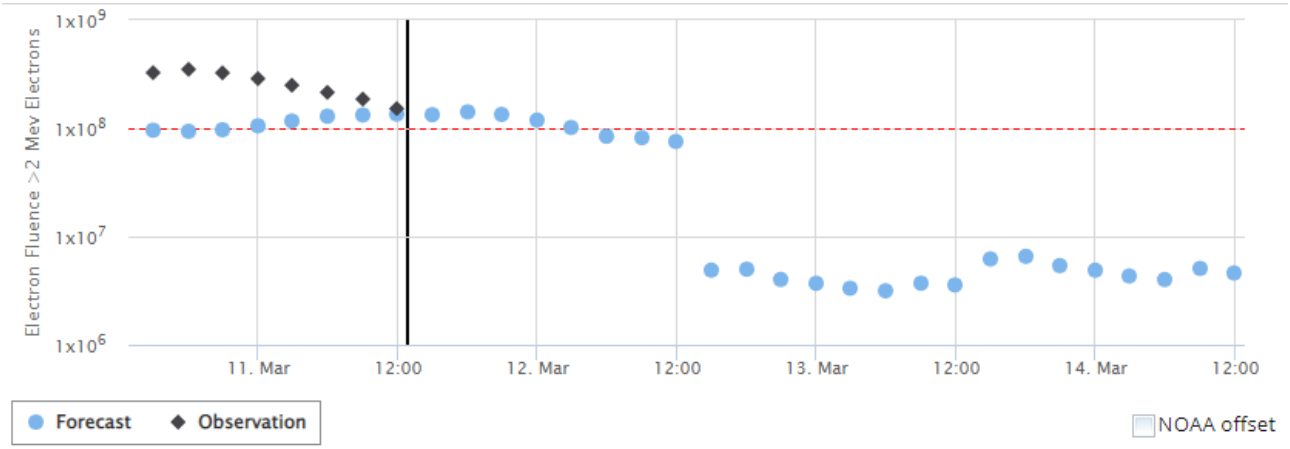
Solar Radiation Storms - (High Energy Protons):
The high energy proton flux (10MeV) measured at GOES 16 is currently slightly elevated, under the residual influence of the CME that was emitted yesterday evening. The high energy proton flux is expected to return and then remain predominantly at background levels, albeit with a slight chance of rising above-the S1 level.
The probabilities have been increased very slightly to reflect the potential of a further large CME, either from the northwest quadrant again or from one of the large and complex sunspot regions on the disc.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 5: Met Office REFM model – fluence is currently above the Active threshold (>2Mev).



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High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2 MeV) electron flux is currently at background to moderate levels, but is likely to rebound to reach High levels again today and also tomorrow, especially at the peaks of the diurnal cycles. During days 3 and 4 (13th and 14th), with an likely increase in geomagnetic activity, the electron flux is expected to decrease to background to moderate levels again.

The corresponding fluence will start above Active levels (1e8 integrated flux) before decreasing below Active through day 2 or 3, although confidence is low regarding this.

The REFM is currently considering to be offering reasonable guidance, showing a decreasing trend in the forecast, although this trend is considered to be too fast.

GEO Electron Environment Probability (Exceedance)	Level ($cm^{-2}\,sr^{-1}\,day^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^{8}$**	Yes	100	60	30	30
Very Active	**≥ 2 MeV ≥ $1x10^{9}$**	No	1	1	1	1

Figure 5:

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